Accident Detection And Avoidance System In Railway Tracks Using IoT

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Abstract*- Railway Track Tracer System for creature detection is a system for detecting cracks on the railway tracks. This system will help to avoid many accidents that occur on rails. This system frequently monitors the railway tracks using a sensor, so that the presence of cracks can be easily identified and then necessary actions can be taken to prevent accidents. Internet of Things is the most studied field and its applications are endless. Internet of Things (IOT) is implemented to provide an up-to-date update on the railway management. In this mode IR sensor is used for checking the availability of the platform. This system is used update the platform availabity to the upcoming train to avoid the prevent accidents. To detect fire and automatic engine detachment. To update the platform availability. There has been an upsurge in railway accidents, which are mostly caused by track quandaries. That might be a misalignment, an obstacle, a crack in one of the track's sides, or some other fault with the track. So, keeping track of all these difficulties is a time-consuming chore for a person. So, we engendered an IoT-predicated Railway Inspection System that includes a sensor-equipped robot car that can identify quandaries on the track which have potential for causing railway accidents, and the sensors utilized to detect this were tilt, ultrasonic, infrared, water, and fire sensors and the movement is controlled using the Relay. In this paper we have built the train track security and Monitoring application. In which we monitoring the rails i.e. tracks of trains with an automated robot which we are passing through this track which will detects and inspects the track status like curve and damages etc. and we are controlling this bot remotely so we are getting all these data via an android app this way are monitoring the track in real time with the track fault detection. So with this data we can prevent the remedies like accidents and train sleeping due to those faulty tracks.*

Keywords- platform availability, fire sensors and data via an android app

I. INTRODUCTION

The railways stand as a paramount and economical mode of transportation, renowned for its efficiency, speed, and safety. Within this domain, Indian Railways proudly holds the title of the largest railway network in Asia and the second-largest globally.

Recognizing the significance of this vast network, even marginal enhancements in the railway sector can catalyse substantial national development. However, the sheer expanse of the railway system demands vigilant monitoring and maintenance to avert potential accidents, as neglect in upkeep poses a significant risk. The introduction of a sophisticated system becomes imperative to address these concerns and ensure the safety of railway operations. A crucial facet of this system lies in its focus on areas where creatures are frequently found on railway tracks. Such locations pose a unique challenge, as the presence of creatures increases the likelihood of accidents. The proposed paper leverages cutting-edge technology, utilizing cameras strategically placed along the railway tracks. These cameras play a pivotal role in identifying the presence of creatures in the vicinity. The system encompasses essential components such as train details, loco-pilot information, an alert system, and the integral camera setup. The process begins with image capture through the cameras, with subsequent recognition facilitated by advanced image processing techniques. In the event that the system detects an object in the captured image, a rapid response mechanism is initiated. Another image is swiftly captured within fractions of seconds, and the image processing algorithm is once again employed. A critical step in this process involves comparing both images. If the system identifies the presence of the object in both images, an alert message is promptly generated by the application. This alert message is not only directed to the loco-pilot, who is at the forefront of ensuring train safety, but is also communicated to the nearby control room. This instantaneous communication ensures that appropriate action can be taken swiftly to prevent potential accidents. By incorporating such a system, the railway sector takes a significant stride towards enhancing safety, minimizing accidents, and safeguarding the lives of those dependent on this crucial mode of transportation. Ultimately, the implementation of such innovative technologies contributes to the overall development and sustainability of the railway infrastructure in the country.

II. LITERATURE SURVEY

Fei Yan etal in his paper introduces system safety analysis methods (Accimap, FRAM, CAST) to overcome shortcomings in traditional accident analysis (Fault Tree, Event Tree). It emphasizes uncovering inconsistencies in human cognition, equipment execution, and train operation in railway control systems, analysing the true logic of accidents. The Singapore metro accident is a case study highlighting operational scenario conflicts as accident sources.

Jiao HAN etal in his paper proposes a semi-automated process to construct a knowledge graph for the past 8 years of railway electrical accidents in China, utilizing a CNN classifier for perfect classification without manual diagnosis. The knowledge graph not only helps analyse and diagnose faulty equipment but also reveals trends, supporting the advancement of intelligent railway electrical systems.

YaoXing Zhang in his paper explains to enhance crack detection for CRTSII ballast less tracks in high-speed railways by proposing an improved YOLOv3 algorithm. They introduce deep separable convolution, inverted residual structure, and SENet in the residual module for efficiency. Using the Mish activation function and path fusion method improves accuracy by 5.3%, and speed by 26%, making it more effective than traditional methods for track slab crack detection

Ranjeeth etal in his paper presents a computer vision-based method for automated railway track crack detection using a rolling camera on a self-moving railway vehicle. The approach involves pre-processing, Gabor transform, and deep learning neural networks, achieving 94.9% accuracy with a 1.5% overall error rate, thereby enhancing efficiency in track inspections and security

Jun Zhang etal in his paper presents a new method for detecting metal cracks using RFID tag antenna-based sensors (TABS) in the UHF band. It explores the feasibility of crack detection via RFID grids, with a focus on enabling widespread adoption of smart skin for structural health monitoring (SHM), especially in railway track health monitoring. The proposed approach enhances non-destructive testing and evaluation (NDT&E) in engineering infrastructures to improve maintenance practices and public safety by identifying cracks related to corrosion and fatigue.

Sandeep Sharma etal in his paper proposes an Automatic Fire-Initiated Braking and Alert System for trains, featuring a microcontroller, motor, fire and smoke sensors, alarm, and alert system. In case of a fire, the system triggers the motor to pull the chain, activates an emergency alert, and sounds an alarm, aiming to minimize damage and protect passenger lives. The embedded system ensures real-time response to fire incidents on trains.

III. EXISTING SYSTEM

The existing system railway tracks are surveyed manually. LED (Light Emitting Diode) LDR (Light Dependent Resister) sensors cannot use on the slab of the tracks. Image processing input images are noisy system and it’s not getting accurate output. This analysis is used to identify the crack in rail track under the bad whether condition which is not getting perfect output. The existing system is found delay in passing the information because still it uses telephonic communication which is not that fast and accurate.

IV. PROPOSED SYSTEM

The proposed system is an enhanced technique for monitoring the object which uses Arduino uno microcontroller, ultrasonic sensor, LCD, and fire module. The ultrasonic will get the distance from the object to detect crack on the railway track. Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. 16x2 LCD used to display the all information. Using fire sensor will detect fire. System will sprinkle and engine detachment during fire attack. Using IR sensors will detect the cracks. This system will check platform availability using IR sensor and send alert to the upcoming train.

A. Objectives

1) *Enhance Safety Measures*: Implement IR sensors for track monitoring to detect obstacles, potential hazards, and cracks, ensuring early identification and mitigation of safety risks. Integrate fire sensors to rapidly identify and respond to fire incidents within train compartments or the railway environment, prioritizing passenger safety.
2) *Optimize Train Movement:* Utilize DC motors for precise control over train acceleration, deceleration, and movement, enhancing overall operational efficiency and passenger comfort.
3) *Automate Emergency Responses:* Employ relays to automate the detachment of train compartments in the case of fire emergencies, preventing the spread of fire and minimizing potential damages.
4) *Fire Suppression Mechanism*: Integrate water pumps to activate automatically in response to fire incidents,

contributing to the rapid suppression of fires within the railway premises.

5) *Real-time Communication:* Utilize Node MCU for real-time communication, enabling immediate message intimation to relevant stakeholders such as authorities, emergency services, and passengers during critical situations.
6) *Seamless Connectivity with Zigbee: To* Implement Zigbee technology to establish the seamless communication between different components of the railway system, facilitating remote monitoring and efficient data exchange.
7) *Platform Availability Monitoring:* Deploy IR sensors for continuous monitoring of platform occupancy and availability, streamlining train scheduling and optimizing passenger boarding processes.
8) *Improve System Resilience:* Design the system to be robust and resilient, ensuring its reliability under various operating conditions and minimizing downtime for maintenance.
9) *Facilitate Remote Monitoring:* To enable the remote monitoring of the railway system to provide authorities with real-time updates on train positions, track conditions, and emergency situations through Zigbee-enabled devices.

B. Design

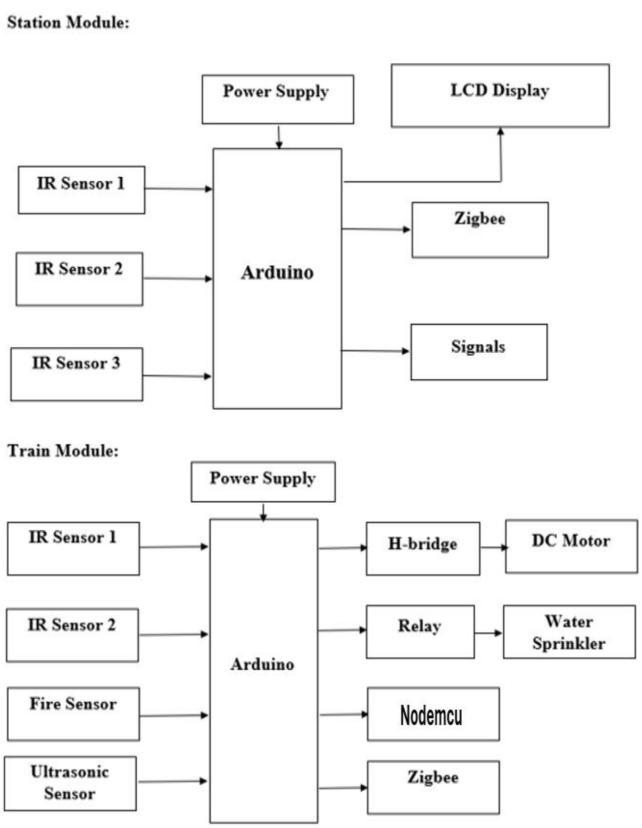

Fig.1 Implemented Block Diagram

1) *System Design and Planning:* Define the overall system architecture and identify the key components such as Arduino boards, sensors, actuators, and communication modules. Establish the system requirements, including safety features, emergency response protocols, and communication interfaces.
2) *Sensor Deployment and Calibration:* Install IR sensors along the railway tracks for crack detection and platform availability monitoring. To deploy ultrasonic sensors for object or human detection on the tracks. Calibrate sensors to ensure accurate readings and responses.
3) *Fire Detection System Integration*: The integration of fire sensors within train compartments and the railway environment. Develop algorithms to interpret sensor data and trigger emergency responses in the event of a fire.
4) *DC Motor Control for Train Movement*: Implement DC motors to control the movement of trains. Develop algorithms for precise acceleration, deceleration, and speed control.
5) *Relay and Water Pump Integration:* Integrate relays to automate the detachment of train compartments in case of a fire. Connect water pumps to the system to activate automatically during fire incidents.
6) *NodeMCU for Real-time Communication:* To *Incorporate* Node MCU for real-time communication between different system components. Develop protocols for message intimation, ensuring timely communication during emergencies.
7) *Zigbee Communication Setup:* To set up Zigbee communication for seamless connectivity between stationary and moving units. Develop communication protocols to exchange real-time data and updates.
8) *Emergency Response Algorithms:* To develop the algorithms to initiate emergency responses based on sensor data, including fire suppression, train compartment detachment, and communication protocols.
9) *Platform Availability Monitoring System:* To deploy additional IR sensors for continuous monitoring of platform occupancy and availability. Integrate platform availability data into the overall system for efficient train scheduling.

C. Methodology

1) *Platform availability:* The principle involved in checking platform availability is when the crack is detected the light does not get reflected to IR sensor and the train stops. Here two IR sensors are placed on all platform and a message

“PLATFORM1 IS AVAIALBLE” or the message “PLATFORM 2 IS AVAILABLE” or “ALL PLATFORM AVAILABLE” or “PLATFORM NOT AVAILABLE” is displayed on the LCD.

2) *Fire detection:* A fire sensor is placed in each compartment. When the flame is sensed, the sensor will alert the controller and relay will be set high and sprinkler will be activated. Stop and Detach () function is called which will stop the movement of the train by clearing the values of motor 1 and motor 2. Another motor (Motor 3) is used to detach the compartment to prevent fire from spreading. The message "FIRE" and "HELP" will be displayed on the LCD. Buzzer is used to alert the passengers about the fire.
3) *Crack Detection:* The infrared (IR) transmitter will be affixed to one side of the rails, while the IR receiver will be placed on the opposite side. Under normal operating conditions, when no cracks are present, the light emitted by the transmitter will not reach the receiver, resulting in a low recorded value. However, when the light from the transmitter reaches the receiver, the recorded value increases, with the increment directly proportional to the intensity of the received light. Consequently, if the transmitted light deviates from its intended path due to the presence of a crack or structural defect, a sudden spike in the recorded value occurs. This abrupt change serves as an indicator of the presence of a crack or similar defect in the rails. To pinpoint the location of the device upon crack detection, a GPS receiver is employed to gather latitude and longitude data. Subsequently, a Node MCU modem is utilized to transmit the received information.
4) *Object Detection:* The concept involved in object detection is YOLOv5 algorithm.

D. Algorithm

Data Preparation: To train YOLOv5 for person detection, a meticulously labelled dataset is crucial. This dataset comprises images containing persons, and each person instance must have corresponding bounding box annotations. The dataset is then split into three subsets: training, validation, and testing. The training set is used to train the model, the validation set aids in hyper parameter tuning and model evaluation, while the testing set assesses the model's performance on unseen data.

Network Architecture: The core of YOLOv5 lies in its Convolution Neural Network (CNN) architecture. This neural network processes the entire input image in a single forward pass, making it highly efficient for real-time object detection. The architecture is intricately designed to predict bounding boxes and class probabilities simultaneously, allowing for a comprehensive understanding of the scene.

Input Processing: Upon feeding an image into YOLOv5, it is divided into a grid. Each grid cell is responsible for predicting objects that may reside within its spatial boundaries. Multiple bounding boxes are predicted by each grid cell, providing a detailed localization of objects. Alongside bounding boxes, confidence scores and class probabilities are predicted, contributing to the overall robustness of the detection.

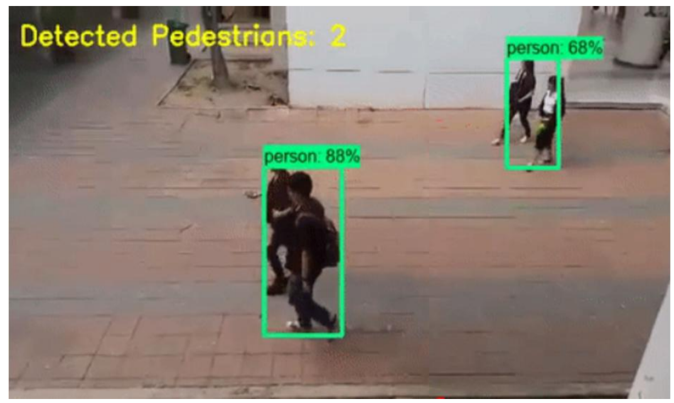

Fig. 1 Example of processing the object

Anchor Boxes: Anchor boxes play a pivotal role in refining the accuracy of YOLOv5's bounding box predictions. These anchor boxes are learned during the training process, adjusting their dimensions based on the distribution of object sizes in the dataset. This adaptive mechanism enhances the model's ability to generalize to different object scales.

Output Prediction: The predictions generated by YOLOv5 include essential information for each bounding box: coordinates (x, y) for the box centre, width, height, confidence score, and class probabilities for each predefined class, such as "person." The confidence score reflects the model's certainty that a particular bounding box indeed contains a person.

Loss Function: During training, YOLOv5 employs a combination of three loss functions. Localization loss penalizes discrepancies in predicting the bounding box coordinates. Confidence loss penalizes errors in estimating the confidence scores, and classification loss penalizes mistakes in predicting class probabilities. This multi-faceted loss function guides the model towards accurate and confident predictions.

Training: The model undergoes training using the labelled dataset. Back propagation and optimization techniques, such as stochastic gradient descent (SGD) or Adam, are applied to iteratively adjust the model's parameters. This training process occurs over multiple epochs, allowing the model to progressively improve its ability to detect persons in diverse scenarios.

Post-Processing: During inference, YOLOv5 produces predictions for bounding boxes around potential persons in input images. To refine these predictions, a non-maximum suppression technique is employed. This method eliminates redundant and low-confidence bounding boxes, ensuring that only the most confident and non-overlapping predictions are retained.

Thresholding: To fine-tune the trade-off between precision and recall, a confidence threshold is applied during post-processing. Bounding boxes with confidence scores below this threshold are discarded, helping control the number of false positives in the final predictions.

Evaluation: The model's performance is rigorously evaluated on a separate validation set. Metrics such as precision, recall, and mean average precision (mAP) are calculated to quantitatively assess how well the model generalizes to new, unseen data. This evaluation phase provides insights into the model's strengths and areas for potential improvement.

E. Advantages

1) *Provides Safety:* The chances of accidents and breakdown of railways are minimized to a greater extend. In case of accidents the system provides quality service.
2) *Efficiently used in remote places:* Because of large carrying capacity of trains the track may get damaged more frequently. By using this system, the rail is checked more accurately even in places where human can't work.
3) *Effective use of time:* Service is provided at faster rate due to which delay of the train can be minimized.
4) *Reduced work:* As most of the work is done automatically the workload of railroad brakeman will be reduced.
5) *Accurate detection:* With the help of IR sensors the exact side (right or left) of crack is detected.
6) *Man power is reduced:* Manual checking of tracks is not required as sensors do the work. And even automatic closure of level crossing is done without the help of gatekeeper.

F. Applications

1) *Railway track damage detection application:* This methodology is used at many places in the tracks where defects due to rail failure occur.
2) *Wireless applications:* This unit is used to intimate the appropriate message using WIFI module.
3) *This solution can be deployed extensively over the long term to enhance safety protocols and establish a robust testing framework for improved outcomes in the future.*
4) *It can also be used commercially in amusement parks to check the tracks for a few rides.*

V. RESULTS

The presented project focuses on leveraging sensor technology for real-time platform monitoring and safety applications. The system integrates various sensors to ensure platform availability and address critical safety concerns. The first aspect involves continuous monitoring for platform availability, utilizing sensors to detect environmental conditions and potential disruptions. A crack detection system has been implemented, employing advanced sensors capable of identifying structural flaws or defects in the platform. Additionally, the project incorporates object and human detection mechanisms, utilizing sensors such as cameras and motion detectors to enhance safety by identifying and tracking the presence of individuals or objects within the monitored area. To mitigate the risk of fire, the system integrates fire detection sensors, promptly identifying potential fire incidents and triggering immediate responses. In the event of any anomaly or safety hazard, the system is designed to generate notification messages, ensuring that users are promptly informed of the situation. This comprehensive sensor-based platform monitoring and safety system contributes to a robust and responsive solution, aligning with IEEE standards for advanced technology applications in the realm of safety and monitoring. The integration of sensor data, detection algorithms, and real-time notifications showcases the potential for advancements in safety protocols and platform integrity in various domains, including industrial, public spaces, and critical infrastructure. The findings of this project, outlined in accordance with IEEE guidelines, underscore the significance of sensor technologies in enhancing safety and operational efficiency.

VI. CONCLUSION

System will help to reduce accidents caused due to railway cracks, fire and accidents happening while arriving train to the platform. An automatic method is used to inspect in railway track for crack detection which helps in maintenance and monitoring the condition of railway tracks without any errors. Automatic opening and closing of gate will reduce the rate of accidents and there is no need for an operator. System uses a fire sensor to detect the fire. Quick actions are taken to avoid spreading of fire to other compartments and alert the passengers.

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